MULTIMEDIA UNIVERSITY®

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023 (TERM ID 2220)

EEL3156 RENEWABLE ENERGY TECHNOLOGY

(All Sections / Groups)

3 JULY 2023
09:00 A.M – 11:00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 8 pages including this cover page with 5 questions only.

2. Attempt all 5 questions. The questions have equal mark distribution. The distribution of marks for each question is given.

3. Please print all your answers in the answer booklet provided.

Question 1

(a) Describe two motivations of renewable energy.

[2 marks]

(b) Write down the 3 types of fossil fuels used as primary energy sources. Which of them are used extensively in electric generation?

[2 marks]

(c) Fig. Q1-1 shows a typical hydropower plant using a Francis turbine. Sketch the variation of water flow speed from the top of the reservoir to the tailrace. Your sketch should include the grid lines as shown in Fig. Q1-2.

[7 marks]

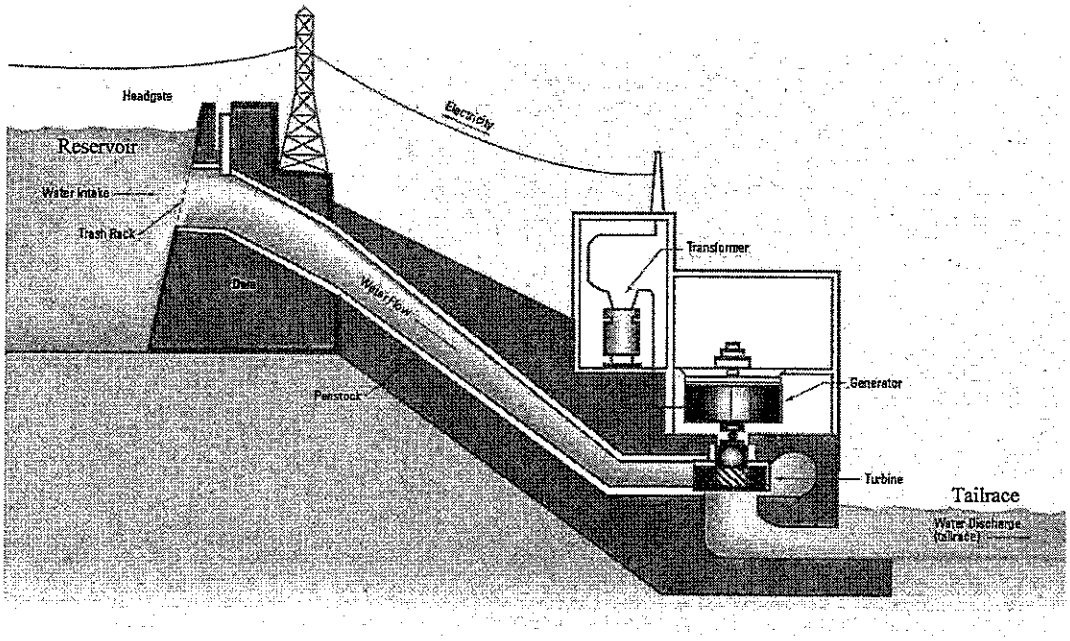

Fig. Q1-1

Continued ...

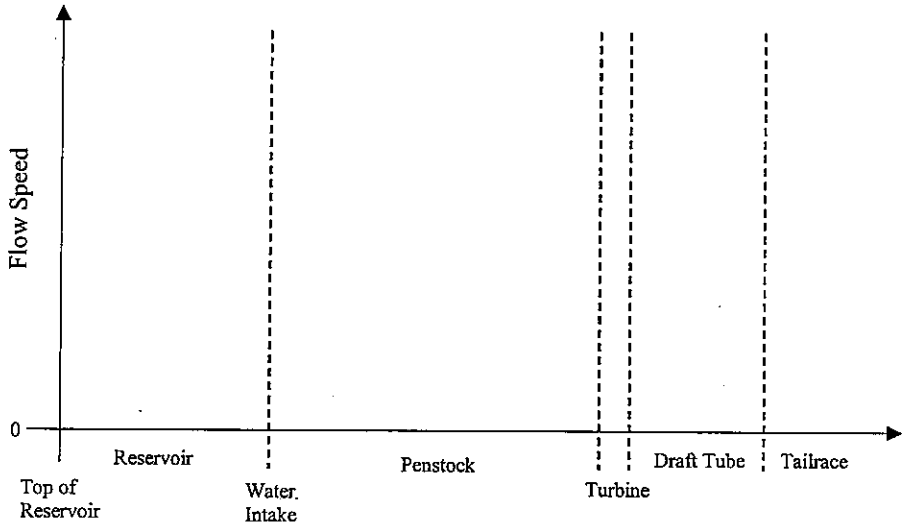

Fig. Q1-2

(d) Discuss three advantages of a large solar farm over a large hydropower station.
[3 marks]

(e) With the aid of a wind turbine power curve, explain the operation of wind turbine at different wind speeds.
[6 marks]

Continued ...

Question 2

(a) Given the solar spectrum shown in Fig. Q2-1, compute the solar irradiance.

[2 marks]

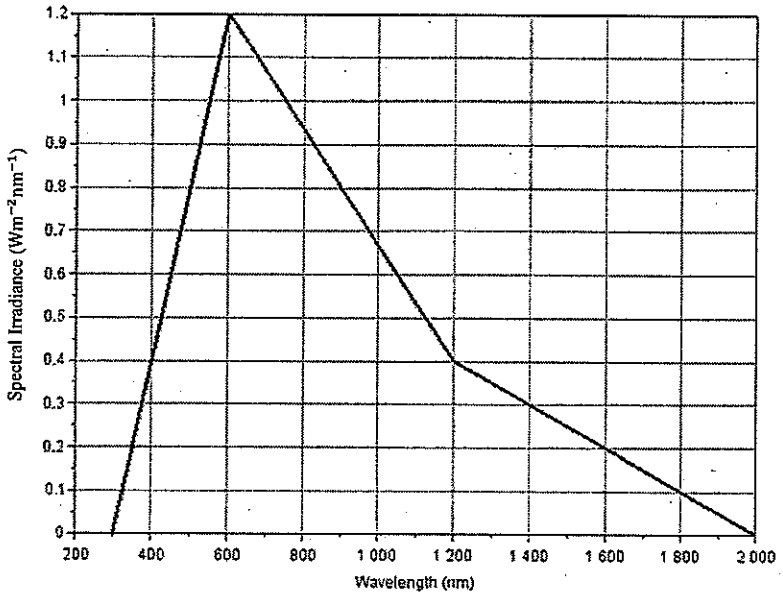

Fig. Q2-1

(b) Given the average daily variation of solar irradiance shown in Fig. Q2-2, compute the daily solar insolation.

[2 marks]

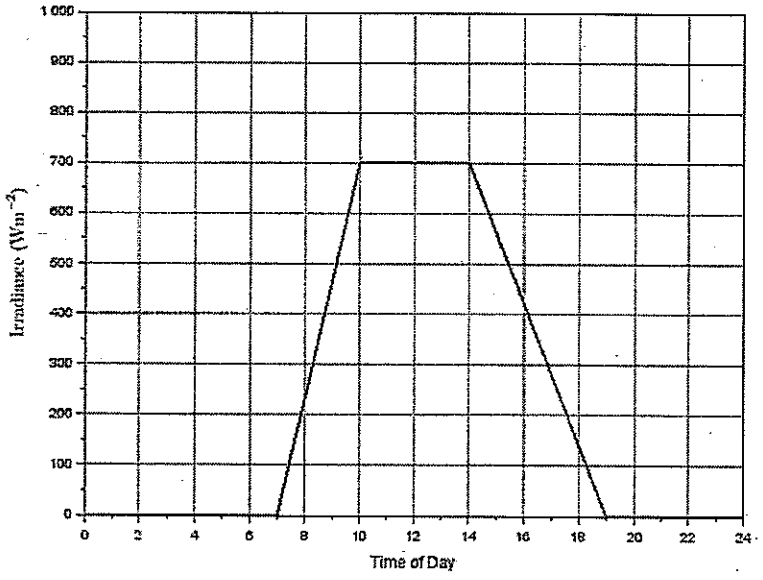

Fig. Q2-2

(c) Explain the heat loss mechanisms (intended and non-intended) of a single glazing flat plate solar thermal collector.

[5 marks]

(d) Sketch the IV (current-voltage) curves of a solar photovoltaic cell to show separately the effects of each of the following:
(i) reduced illumination,
(ii) reduced shunt resistance, and
(iii) increased series resistance.

[7 marks]

(e) Compare and contrast "torrefaction" and "gasification".

[4 marks]

Continued ...

Question 3

(a) A hydropower plant has the following specifications:

Available water head:	90 m
Flow rate per turbine:	800 m^3/s
Turbine type:	Francis turbine with shape number ~1.5
Number of turbines:	20 (each is paired with one generator)
Turbine efficiency:	94%
Generator efficiency:	96%
Annual generation:	100 TWh
Output frequency:	50 Hz
Water density:	1000 kg/m^3
Gravity acceleration:	9.81 m/s^2

Determine the following:

(i) The capacity factor.

[5 marks]

(ii) The generator type if it is coupled directly to the turbine with 1:1 speed ratio.

[5 marks]

(b) A horizontal axis 4-bladed wind turbine has the following specifications at optimal operating condition:

Power coefficient, C_p:	50 %
Blade length:	50 m
Tower height:	90 m
Air density:	1.2 kg/m^3

Determine the following for a wind speed of 10 m/s at optimal operating condition:

(i) The optimal tip-speed ratio.

[3 marks]

(ii) The turbine's output power.

[3 marks]

(iii) The turbine's working torque.

[4 marks]

Continued ...

Question 4

(a) A flat plate single glazing solar thermal collector has the following specifications:

Area:	$10\ m^2$
Irradiance:	$600\ Wm^{-2}$
Heat resistance:	$0.15\ W^{-1}m^2K$
Plate-fluid transfer efficiency:	85%
Glass cover transmittance:	90%
Absorber absorptance:	92%
Absorber emittance:	8%
Ambient temperature:	$32°C$
Plate temperature:	$60\ °C$

Determine the output power.

[5 marks]

(b) A solar photovoltaic system has the following specifications:

Area:	$10\ m^2$
Annual insolation:	$2200\ kWh/m^2$
Rated DC output power:	$1500\ W_p$
Specific yield:	$1350\ kWh/kW_p$

Determine the performance ratio.

[5 marks]

(c) A biogas digester is capable of processing manure from about 2000 dairy cow. On average, each dairy cow produces 35 kg wet manure with 87% moisture per day. Water is mixed to the manure to make a slurry of 50 kg solid per m^3. The retention time is 22 days. The biogas yield per unit dry mass is about 0.25 m^3/kg. The heat of combustion per unit volume biogas is about 20 MJ/m^3. If the biogas is supplied to a biogas-fired electric generator set at 25% efficiency, determine the electric output power.

[5 marks]

Continued ...

(d) A hot aquifer has the following specifications:

Depth:	4.5 km
Thickness:	400 m
Average surface temperature:	$30°C$
Temperature gradient:	$45\ °C$/km
Useful temperature:	$\geq 100°C$
Porosity:	5%
Sediment density:	2700 kg/m^3
Sediment specific heat capacity:	840 J kg^{-1} K^{-1}
Water density:	1000 kg/m^3
Water specific heat capacity:	4200 J kg^{-1} K^{-1}
Water flow rate:	0.3 m^{3}s^{-1}km^{-2}

Determine the cooling time constant in years.

[5 marks]

Question 5

(a) Explain how renewable energy sources affect the supply-demand balance of the utility electric grid and the implication.

[3 marks]

(b) Explain the fundamental difference between off-grid and grid connected inverters. You need to explain why such a difference is necessary.

[5 marks]

(c) A residential home installed an off-grid solar photovoltaic system at rooftop. The solar irradiance is not uniform across all the solar panels. Cost precedes scalability and reliability. Propose a suitable inverter system for the above application scenario. Justify your proposal by comparing the different types of inverter systems.

[7 marks]

(d) The Malaysian government has introduced a number of schemes to promote renewable energy production. A commercial building owner wishes to take advantage of one of these schemes to install rooftop solar panels to reduce the electricity bill.

a. Which scheme would you propose?
b. What benefits will the building owner gets from the proposed scheme?

[5 marks]

End of Paper